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Review of wind energy use in Algeria

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Abstract

Most scientists now agree that human-induced global climate change poses a serious threat to both society and the Earth's ecosystems. Renewable energy holds the key to future prosperity and a healthy global environment and is considered as a promising way to solve the problem of environmental pollution such as major environmental accidents, water pollution, maritime pollution, land use and sitting impact, radiation and radioactivity, solid waste disposal, hazardous air pollutants, ambient air quality (CO, CO_2, SO_x, NO_x effluent gas emissions), acid rain, stratospheric ozone depletion, and global warming (GHG). Solar, wind and hydrogen power can be considered as potential renewable energy sources in Algeria. The share of renewable energy sources in Algeria primary energy supply is relatively low compared with European countries, though the trends of development are positive. One of the main strategic priorities of New Energy Algeria (NEAL) which is Algeria's renewable energy agency (government, Sonelgaz and Sonatrach), is striving to achieve a share of renewable energy sources in primary energy supply of 10–12% by 2010. IEA projects that the fastest growing sources of energy will be supplied by renewables. Much of this capacity will be installed in developing nations where solar and wind electric power is already competitive. Clearly, the nation that can capture a leadership position has potential for substantial economic returns. The article presents a review of the present wind energy situation and assessed potential of wind energy sources in Algeria in particular the southwest region of Algeria (Adrar, Timimoun and Tindouf).

Keywords: Wind energy source; Power production

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1. Introduction

At the current rate of usage, taking into consideration population increases and higher consumption of energy by developing countries, oil resources, natural gas and uranium will be depleted within a few decades (Fig. 1) [1]. As for coal, it may take two centuries or so. One must therefore endeavour to take precautions today for a viable world for coming generations. As world populations grow, many faster than

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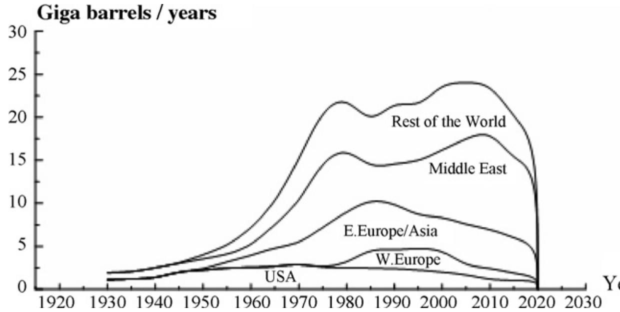


Fig. 1. World oil production in the next 10–20 years.

the average 2% [2], the need for more and more energy is exacerbated. Renewable energy sources that use indigenous resources, such as solar and wind power, have the potential to provide energy services with zero or almost zero emissions of both air pollutants and greenhouse gases (Table 1) [5]. Currently, renewable energy sources (RES) supply 20% of the total world energy demand. The supply is dominated by traditional biomass used for cooking and heating, especially in rural areas [3]. During the last few years, political support for renewable energies has been growing continuously both at the national and international level [3]. One hundred and fifty-five countries, including Algeria, have signed the United Nations Framework Convention on Climate Change (UNFCCC) in Rio de Janeiro on June 1992. Countries which signed the UNFCCC in 1997 agreed on the Kyoto Protocol and committed themselves to reduce emissions of GHG to at least five per cent below their average 1990 levels by 2008–2012. (GHG emissions may not exceed 39 million tons in 2008–2012) [3].

World Summit on Sustainable Development held in Johannesburg adopted a joint declaration on "The way forward on renewable energy", which recommended promoting diversified energy supply by developing advanced energy technologies, including fossil fuel and renewables. The Fifth Ministerial Conference on Environment for Europe in 2003 stressed the importance of actions to be taken to substantially increase the global share of RES (willing share of 15%).

Algeria has ambitious quantitative targets for renewables. The energy strategy, in association with the European community, has set up a target for 2010, with RES generating 10–12% of the energy supply of which electricity produced by RES should amount to 7–8% [4].

According to the Special Report on Emission Scenarios issued by the Intergovernmental Panel on Climate Change (IPCC) under the auspices of the United Nations (UN), by the end of the 21st century, nations could expect to see carbon dioxide concentrations of anywhere from 490 to 1260 ppm (75–350% above the pre-industrial concentration) [6,7]. The Arab region, that includes Algeria, represents about 15% of the world's total primary production [8]. Energy consumption within the region has more than tripled during the period 1980–2004, from 6.27 quadrillion btu to 21.48 quadrillion btu as seen in Table 2 [8,16] that includes the energy production in the Arab region as well as Algeria in particular. CO_2 emission is also provided.

According to some estimates, more than five million Algerians do not have access to grid electricity, while many rural communities are in need of drinking water and water for livestock or irrigation. Given Algerian's abundant solar and wind resources, these rural needs represent a potential market for renewable energy technologies.

A growing number of people in the South of Algeria are starting to use renewable energy technology to irrigate their land, light their houses, pump well water, thus improve their living conditions, thanks to the "Energy and Mining Ministry" and Sonelgaz R&D Office. The renewable energy projects are tools for the management of reserves and sustainable development of desert communities. There are generally areas where a diesel or gas-powered generator present a problem of fuel transportation and may potentially harm the environment. This program aims at increasing the use of renewable energy

Table 1
Pollutant emission factors for the total and non-generating portion of the fuel cycle

Energy source	SO_x (gSO_x/kWh)	NO_x (gNO_x/kWh)	C in CO_2 (gC/kWh)	C in CO_2[a] (gC/kWh)
Coal	3.400	1.800	322.8	50.0
Oil	1.700	0.880	258.5	50.0
Natural gas	0.001	0.900	178.0	30.0
Nuclear	0.030	0.003	7.8	7.8
Photovoltaics	0.020	0.007	5.3	5.3
Wind	0.018	0.003	1.7	1.1

[a] From non-generating portion of fuel cycle.

Table 2
Primary production and consumption and CO_2 emission in the Algeria and the Arab region

	Energy production[a]			Energy consumption[a]			CO_2 emission[b]		
Year	1980	1999	2004	1980	1999	2004	1980	1999	2004
Algeria	2.8	6.06	10.03	0.8	1.31	6.21	16.44	23.42	28.60
Arab region	46.82	55.57	62.54	6.27	15.59	21.48	141.65	268.40	354.21

[a] Quadrillion (10^{15}) British thermal unit (1055.54 J).
[b] Million metric tons.

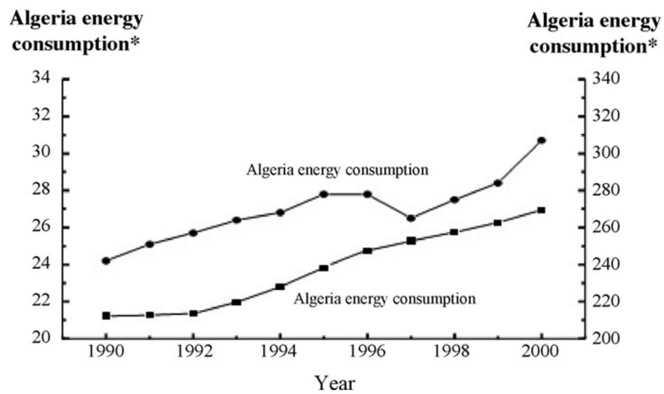


Fig. 2. Energy demand of Algeria and Africa (*million of tons of oil equivalent).

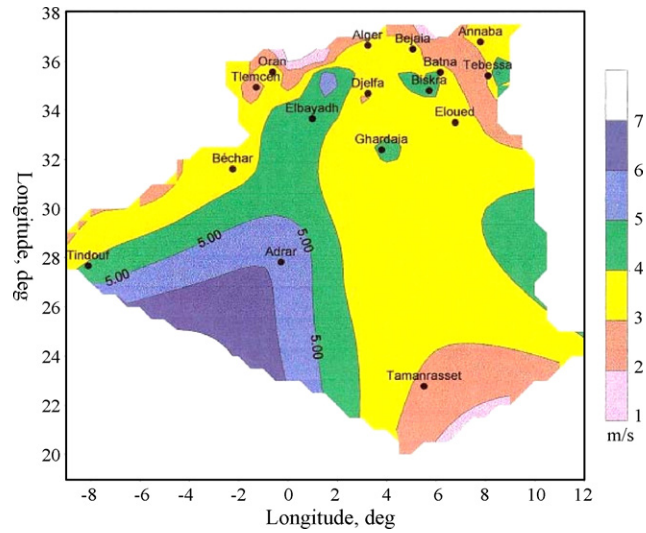


Fig. 3. Wind map evaluation in Algeria [9].

technologies in Algeria, therefore providing green power to isolated villages and combating global climate change, especially greenhouse gas emissions [9].

2. Topography of Algeria and energy data for Algeria

Algeria's geographic location has several advantages for extensive use of most of the RES (solar and wind). Algeria situated in the centre of North Africa between the 38–35° of latitude north and 8–12° longitude east, has an area of 2,381,741 km^2 and a population of 32.5 millions of inhabitants (13.7 inhabitant/km^2) [10]. The Sahara occupies the 80% of the area [10]. It lies, in the north, on the coast of the Mediterranean Sea. The length of the coastline is 2400 km. In the west Algeria borders with Morocco, Mauritania and occidental Sahara, in the southwest with Mali, in the east with Tunisia and Libya, and in the southeast with Niger. The climate is transitional between maritime (north) and semi-arid to arid (middle and south). The mean annual precipitation varies from 500 mm (in the north) to 150 mm (in the south). The average annual temperature is about 12 °C [11,12].

3. Energy data for Algeria

Algeria's revenues come mainly from exporting fossil fuels. These resources are limited and they have been declining. Algeria could face an energy deficit within the next 30 years. Reserves announced in Algeria are 4, 5 billion of tons equivalent petrol (TEP). Estimates of natural gas reserves, in 2004, are around 4.52×10^{12} m^3, which implies a lifetime of 62 years. From the annual 35 millions of TEP products, 40% are exported. First resource of Algeria, hydrocarbons are at the world level the most coveted raw material. The dynamics of final energy consumption of Algeria and Africa, from 1990 till 2000 is presented in Fig. 2.

4. Meteorological data and wind energy projects

Wind energy can be feasible where the average wind velocity is higher than 5–6 m/s [9]. Algeria has a huge plan to develop wind energy. Studies of indigenous wind resources in Algeria performed by Centre de Développement des Energies Renouvelables (CDER) during recent years show that the climatic conditions in Algeria are favourable for wind energy utilisation [9,13] as seen in Fig. 3. This wind map shows that 50% of the country surface presents a considerable average speed of the wind. The best wind energy potential is in the South especially in the southwestern region where the wind velocity is higher than 6 m/s [9] as seen in Table 3 showing the annual average wind velocities and power in the three sites of the southwest region of Algeria.

The wind resource has been assessed by the developer, Sonelgaz, and at present, there are six supplementary projects using wind for electrification and telecommunication are identified and quantified. These are Adrar, Tindouf, Bordj Badji Mokhtar, Béchar, Tamanrassat and Djanet [9]. The annual average wind velocities in these six places are shown in Table 4. The installation, by Sonelgaz, of nine assessment stations in different regions of Algeria is seen as a second step in stimulating much faster the use of the wind power [9]. Fig. 4 presents the nine stations throughout Algeria. The topography and terrain roughness of these prospective wind sites are also measured and quantified to better simulate and understand the wind flow.

Table 3
Location, average velocity and wind power density of each of the three sites

Site	Latitude	Longitude	Altitude	Average velocity (m/s)	Wind energy power (kWh/m^2/year)
Tindouf	27°40′N	08°06′W	401	8.7	215.50
Adrar	27°49′N	00°17′E	263	9.8	308.82
Timimoun	29°15′N	00°17′E	312	9.4	242.30

Table 4
The annual average wind velocities in the six identified places

Sites	Adrar	Tindouf	Bordj Badji Mokhtar	Béchar	Tamanrassat	Djanet
Annual average speed (m/s)	6.3	5.1	4.6	4.4	3.7	3.3

Table 5
A total list of power production with wind power source up to 2015

Project and place	Capacity (MW)	Bill-book	Cost ($ $\times 10^6$)	Observation
WPP1.Tindouf	6	2006–2007	13	Wind power plant
WPP2.Tindouf	10	2008–2010	23	Wind power plant
WPP3.Timimoun	10	2010–2012	23	Wind power plant
WPP4.Bechar	10	2015	23	Wind power plant
Total	36	–	82	–

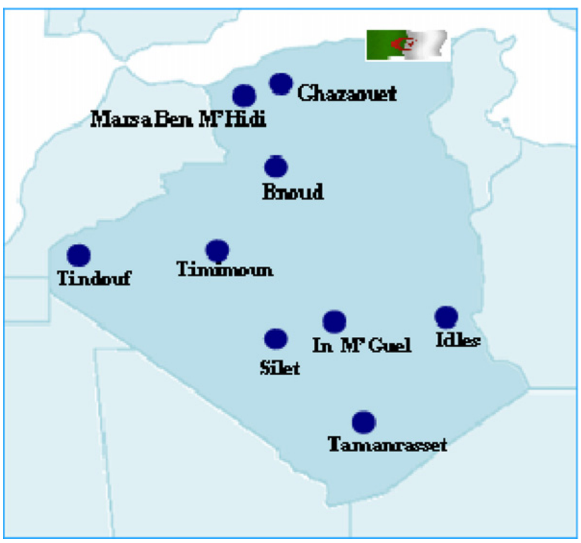


Fig. 4. Nine assessment stations throughout Algeria [9].

The NEAL efforts are reflected in a second project: a wind energy farm of 10 MW in Tindouf, of which global cost is €13 millions [17]. Within this frame, there is an Algerian and German cooperation concerning the CO_2 emission purchase planned by the Kyoto protocol [14].

It is important to note that the Western European experience shows that the power price for wind power plants, when the wind velocity is 5–6 m/s, is around €0.20–0.25 [15].

The Algerian Government has been promoting the use of wind energy by means of a series of laws and official programmes Table 5 [17]. NEAL has solicited several sources of funding and supporting its projects. On the one hand the projected objectives is included within a solicited actions supported and financed by World Bank. AIE and the European bank of investment. Whereas on the other, it also receives funds from the Algerian Government.

5. Conclusion

Electricity in Algeria could be produced by hydro, solar and wind power, as well as combined heat and power (CHP). Regarding small-scale hydropower, it is only possible to augment the production slightly. The electricity produced by wind should amount for the rest. The RES producing heat would be: wood, straw, peat, and geothermal. Practical applications of wind energy, however, are still limited due to the high costs and the need for advances in technology. It is now important in educating the public as well as introducing special energy legislation to increase the usage of this clean form of energy whether in private or public sectors and show the importance of energy efficiency and conservation. Solar and wind energy are the most abundant natural resource in Algeria. It becomes imperative for Algeria to exploit this important energy resource. Overall, Algeria hopes to increase the share of these sources in the country's electricity mix to 10% by 2010.

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